On the Difference of Longitude between Mr. Tebbutt's Observatory, Windsor, New South Wales, and the Government Observatories at Sydney and Melbourne. By John Tebbutt.

On a single evening both in 1865 and 1878 the difference of longitude between my observatory and the Sydney Observatory was determined by telegraphic signals, the results being respectively $1^m 30^s\cdot04$ and $1^m 28^s\cdot83$. The time at Windsor for both these provisional determinations was derived from observations with a 2-inch transit instrument, and the preference was given to the latter result. As the longitude of Windsor was determined with great precision in 1884, by Dr. Auwers, from a long list of lunar occultations of stars, it was thought advisable in 1885 to redetermine the difference of longitude with all possible accuracy, inasmuch as more improved means existed here for the determination of the local time. It was therefore arranged to exchange telegraphic signals on three evenings in May 1885. As my observatory was not itself telegraphically connected with the Sydney Observatory, a mean-time chronometer had to be carried to the local telegraph office, distant about half a mile, for the transmission and reception of the signals. Signals were sent by hand to Syndey at every tenth second of the chronometer and recorded there on the transit-clock chronograph. It was arranged to receive seconds-signals from the Sydney clock, and to compare them with the chronometer by the method of coincidence of beats, but owing to the length and indefiniteness of the signals the attempt did not succeed. On the last evening signals were sent by hand from Sydney at every tenth second, being recorded there on the chronograph and compared at Windsor with the mean-time chronometer. In the autumn of last year it was suggested by Professor Harkness, of Washington, that the longitude from both Sydney and Melbourne should be determined with all possible care. During the winter several series of signals were accordingly exchanged between Windsor and the two observatories. The signals from Windsor were sent by hand from the local telegraph office at every tenth second by means of a mean-time chronometer, which was itself compared by coincidence of beats with the standard sidereal chronometer of my observatory both immediately before and after the exchange of signals, the latter timekeeper being regulated by the observation of a group of stars both shortly before and after the signals. The signals were recorded on the transit-clock chronograph at Sydney or Melbourne. The signals received at Windsor were sent at every second by the Sydney or Melbourne clock for the space of fifteen or twenty minutes with a break at the end of every minute, and compared with the mean-time chronometer by the method of coincidence of beats. On several occasions I also made trips to Sydney by railway in order to compare a mean-time chronometer with my standard

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sidereal chronometer and the Sydney transit-clock. The comparisons of the chronometers were made by watching for the coincidence of beats, and those of the mean-time chronometer and the clock either by this method or by signals with the observing key recorded on the clock chronograph. As the mean-time chronometer was usually absent from my observatory only about twelve, and never more than twenty-four hours, the results from the transportation of the chronometer ought to be fairly good. The personal equation between Mr. Lenehan and myself was obtained from three evenings' observations at the Sydney Observatory. There has been no opportunity for determining that between Mr. White and myself. It appears that some years ago the Lenehan-White was found to be $+0^s\cdot12$, and this, combined with the value Tebbutt-Lenehan $+0^s\cdot06$, gives $+0^s\cdot18$ as a probable approximate value for Tebbutt-White.

With the foregoing brief explanation of the method adopted in the determination of the differences of longitude I now submit the following results of my investigation, and I trust to be able in the course of a short time to publish in a separate form the details of the work.

Difference of Longitude, Sydney–Windsor, from Telegraph Signals.

Date.		Signals.	Coincidences.	Windsor to Sydney.	Sydney to Windsor.
				m s	m s
1885, May	28	35	...	1 29·29	...
	28	17	...	1 29·24	...
	29	22	...	1 29·33	...
	29	35	...	1 29·34	...
	29	37	...	1 29·36	...
	30	42	...	1 29·32	...
	30	29	...	1 29·31	...
	30	37	...	...	1 29 34*
1887, June	8	21	...	1 29·37	...
	8	...	4	...	1 29·36
July	7	22	...	1 29·39	...
	7	...	5	...	1 29·36
	7	...	5	...	29·39
	7	22	...	1 29·28	...
Mean of all, with equal weights		...		1 29·32	1 29·36
Personal equation, T.–L.		...		+0·06	+0·03
Difference of longitude		...		1 29·38	1 29·39

Mean = 1 29·39

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* This difference was obtained by estimating the fractions of the half-seconds of the chronometer corresponding to the Sydney signals.

Difference of Longitude, Sydney–Windsor, from the Transportation of the Chronometer.

Date.	Key Signals.	Coincidences.	Difference of Longitude from Observer's key and chronograph. m s	Coincidence of beats. m s
1887, May 13	...	13	...	1 29·47
20	...	10	...	1 29·48
June 3	...	9	...	1 29·21
July 8	...	10	...	1 29·38
20	21	...	1 29·40	...
20	22	...	1 29·38	...
20	...	6	...	1 29·45
Nov. 24	18	...	1 29 75	...
24	19	...	1 29·70	...
24	...	5.	...	1 29·72
Dec. 14	21	...	1 29·27	...
14	14	...	1 29·27	...
14	...	5	...	1 29·28
Mean of all, with equal weights	...		1 29 46	1 29·43
Personal equation, T.–L.	...		+0·06	÷0 03
Difference of longitude	...		1 29·52	1 29·46

Mean = 1 29·49

Difference of Longitude, Windsor–Melbourne, from Telegraphic Signals.

Date.	Signals.	Coincidences.	Windsor to Melbourne. m s	Melbourne to Windsor. m s
1887, June 13	22	...	23 25·86	...
13	...	4	...	23 25·96
13	10	...	23 25·88	...
15	22	...	23 26·05	...
15	...	3	...	23 26·08
15	...	4	...	23 26·22
15	22	...	23 26·09	...
23	22	...	23 26·00	...
23	...	5	...	23 26·19
23	22	...	23 26·05	...
Aug. 15	19	...	23 25·87	...
15	...	8	...	23 26·18
15	19	...	23 25·92	...
Mean of all with equal weights	...		23 25·97	23 26·13
Correction for assumed personal equation, T.–W.			−0·18	−0·18
Difference of longitude ...	...		23 25·79	23 25·95

Mean = 23 25·87

It will be seen that the sum of the telegraphic mean differences in the preceding tables is 24^m $55^s \cdot 26$, which is less than the result obtained directly between Sydney and Melbourne, and published in the " Report on the Telegraphic Determination of Australian Longitudes," by $0^s \cdot 14$.

I may add that I have recently made a trigonometrical connection between my transit instrument and the north terminal of the Government base-line, about three miles nearly due west of my observatory.   As the terminal could not be seen from the observatory, the position of an intermediate well-defined object was determined from bases at the observatory and the terminal. The chief officer of the Trigonometrical Survey here gives the following as the position of the terminal :

Longitude west of Sydney Observatory $= 1^m$ $42^s \cdot 73$

Geographical latitude $\qquad = -33° 35' 58'' \cdot 07$

The differences of longitude and latitude between my transit instrument and the terminal as deduced trigonometrically are :

Longitude of terminal west $= 12^s \cdot 96$

Latitude of terminal north $= 32'' \cdot 41$

A comparison of these results gives 1^m $29^s \cdot 77$ as the longitude of my transit instrument west of the Sydney transit-circle. This is somewhat larger than the value obtained from the exchange of time signals with Sydney. Again adopting the above latitude of the terminal, I get $-33° 36' 30'' \cdot 48$ as the latitude of my transit instrument, which differs only $0'' \cdot 3$ from the value obtained directly from prime vertical observations in 1881.   The trigonometrical work was performed with an ordinary steel tape and a common theodolite reading only to minutes of arc.   The two triangles formed were ill-conditioned, but I nevertheless think the work was sufficiently accurate to give the difference of longitude to $0^s \cdot 01$ and that of latitude to $0'' \cdot 1$.

Private Observatory, Windsor, N. S. Wales :
1888, February 24.

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Erratum in Mr. Bryant's Paper, vol. xlviii. page 96.

The R.A. of Star No. 16 should be 13^h 26^m 47^s instead of 13^h 25^m 47^s.